Operant Conditioning and Generalization
in Two-Month-Old Infants

By

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To my children

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There were three specific areas of inquiry that provided the framework for this study. The first area or purpose was to investigate some aspects of operant conditioning with two-month-old infants, in particular, chaining. The second purpose of the study was to examine the role differences in stimuli play in obtaining conditioning effects. The third purpose was to examine the separate components of the learning process, the babies and the stimuli. Very little research has been done with conditioning of infants this young, and no studies of chaining have been reported.

There were two males and two females who served as experimental subjects (_Ss_). A fifth _S_ served as a control. Their average age was 70 days at the beginning of the study. Before conditioning six five-minute baselines (Baseline I) vocalization measures were taken under varying conditions. During the days when Baseline I was being recorded,

the experimenter observed and assigned activity measures on a one to three scale to each *Ss* under five conditions.

Conditioning involved reinforcing the *Ss*' vocalizations with auditory stimulation (mother's voice) and tactile stimulation on the leg on a crf schedule. The discriminative stimulus (S^D) for two *Ss* was their own mother's face. For the other two the S^D was a brightly colored mask of a human face. After several sessions, the chaining procedure was initiated. A curtain was placed between the *S* and his mother so that the S^D could be removed from view. When the *S* made a leg kick response, mother's face or mask came into view for the *S*. When *S* vocalized, reinforcement was applied, and mother again withdrew from view. After the chaining sessions, the original six measures (Baseline II) were taken over two or three days.

The results indicated that activity level was related to vocalization rate before conditioning. The more active babies, the males in this study, had higher vocalization rates. However, there did not appear to be any consistent relationship between activity level and performance during conditioning and chaining. When differences in S^D were compared to performance, the *Ss* who had mother as the S^D had slightly higher vocalization rates during conditioning and chaining than those who had the mask.

The data obtained during the conditioning phase suggested the vocalization rates of two of the *Ss* had come under control of reinforcement, while the data of the other two were equivocal. Vocalization rates across sessions were higher for all *Ss* during chaining than during conditioning. The strongest evidence for chaining was in the change in leg kick rates across sessions, and these data suggested that chaining was established with three of the Ss. All Ss achieved rates of vocalization well above baseline by the end of chaining sessions. Baseline II showed an increase in vocalization rate across most measures for all Ss except the control. These increases suggested that there were some generalization effects for all Ss and that both the stimuli used in conditioning and the history of the S determine the unique pattern for each infant.

While the method and discussion were presented primarily within an operant model, describing the results in a Piagetan framework provided an additional direction for further research. The response sequences established during chaining resemble secondary circular reactions, and the data suggested that movement from one stage to another may be facilitated by experience. Operant methods could be useful in providing techniques by which one could determine how much generalization in schemas is necessary for the infant to move into the next level of complexity.

CHAPTER I

INTRODUCTION

Research in human development, a neglected field during the past twenty-five years, is experiencing a renaissance in American psychology. There are several possible explanations for this delayed exploration. An obvious problem has been the lack of technical skills and tools necessary for sufficient experimental control. Recent advances in the area of recording and measurement have provided impetus for infant research that would have been methodologically impossible previously. The recent translation of Russian and Eastern European literature has also helped. Furthermore, the infant himself is not the easiest of subjects to study, particularly since he seems to lack any motivation to cooperate at this stage in development, and many researchers have preferred a population less demanding of their creativity, endurance, and technological sophistication.

A less obvious but perhaps more pervasive reason for the delayed interest in the area has involved the underlying theoretical orientation of developmental psychology. For many years the focus of the developmental psychologist has been on establishing the characteristics of particular stages of development, depending on his individual theoretical point of departure. Regardless of the theoretical framework, whether Freudian or behavioral, the tendency has been to conceptualize the infant or child primarily as a biologically maturing or unfolding organism. Individual differences were recognized, to be sure, but always within a vague, genetically determined set of limits. Environmental factors influenced behavior but not beyond activating the given potential for a certain individual or stage. One had to wait until the child was "ready" before he could have much impact on development.

Along with this orientation went the view that the human infant was a structurally immature organism, not even equipped to experience the external world as any more than total confusion, let alone be motivated to organize it. Marquis (1931) indicated that investigators prior to her study had not been able to observe respondent conditioning in babies less than five months and that the explanation for this was the incomplete development of the infant's cerebrum. Watson (1966) postulated that babies experience a natural deprivation period during their first three months because their motor development does not allow them to process information from the environment within the critical times required. The implications of this orientation are obvious in armchair debates on which behaviors are a result of environment and which are genetically determined. Fortunately, sufficient evidence has now been accumulated to encourage a re-evaluation and a trend toward a broader, more inclusive developmental approach that may eventually be interdisciplinary in scope (Fantz, 1956; Horowitz, 1968; Sigel, 1968).

It is with this background in the general area in mind that the subsequent review of the studies in infant learning is to be presented. The general plan is to indicate for the reader some of the early work done in infant conditioning, to look at more recent trends, and to review more specifically the work which prompted this study. Since this review was originally written, a much more comprehensive review of both classical and operant studies in the last decade has been drafted for publication by Fitzgerald and Porges (1970). The reader is invited to check their paper if a more detailed reporting of recent studies is required.

Classical Conditioning

Wenger (1936) presented a brief review of infant classical conditioning that is quite representative of the early studies. He cited Krasnogorski (1909) as stating that classical conditioning was not possible before the infant was 3 months of age. This was congruent with two prevalent viewpoints at the time, namely, that cortical function is necessary for the establishment of conditioned responses (Pavlov, 1927), and that the cortex of the neonate is nonfunctional (Flechsig, 1876). Wenger evaluated the work of Marquis (1931) who reported unstable conditioned responses in newborn infants. She concluded that since the evidence at that time indicated that the cerebral cortex of the newborn infant functions very incompletely for the first few months after birth, one may infer that conditioned responses can be formed by subcortical stimulation. She bottle-fed ten newborn infants and conditioned sucking reactions to the sound of a buzzer.

Wenger criticized the findings of Marquis and concluded that prior to his own work conditioning in the fetus or neonate had not been equivocally demonstrated. After his own series of experiments, he concluded that it is possible to establish some forms of conditioned responses in some newborns but that conditioning is unstable and not easily established.

Another classical study was done by Morgan and Morgan (1944) who suggested the conditioned eyeblink as a useful developmental index. They gave 42 infants from 5 to 75 days of age 100 conditioning trials. They found that no child 53 days of age or younger conditioned and that only one failed to condition after 66 days. They concluded that maturation was important in determining the ability of the infant to learn a simple conditioning reaction. This supported the notion that before a certain stage of maturation has been reached, the infant would be unable to learn the lesson involved; but when he could not learn after he was physically mature enough, an additional factor, perhaps intelligence, might be responsible.

Lipsitt (1963) in a review of the Morgan and Morgan data thought that there was a sufficient lack of control of experimental conditions to seriously question their lower limit on age. Several studies with older infants have been reported using both classical appetitional and classical aversive conditioning. Kantrow (1937), for example, paired the sound of a buzzer with the presentation of a bottle to infants ranging in age from 44 to 117 days. She reported that from 16 to 72 paired presentations were necessary to establish stable anticipatory suckings.

In sum, these and similar studies have suffered from two sources of difficulty. First, the experimenters were plagued with methodological problems, including poor instrumentation. Methodological problems led to a lack of control which, in turn, tended to weaken or invalidate the findings in many of the studies. Secondly, the studies were usually intended to support or deny the learning position in favor of the traditional maturational approach. Not only did this kind of orientation in purpose prove extremely difficult to settle one way or the other, later it also proved to be an irrelevant question in many cases.

Recent studies suffer from similar difficulties as the older ones but to a lesser degree. The tendency now seems to be away from a rigid theoretical approach to a more flexible experimental approach. Horowitz (1968) reviewed the studies on infant learning and development from 1957 until 1966. The conditioning procedures varied and included conditioning of the smiling response (Brackbill, 1958), the head-turning response (Papousek, 1959), the orienting reflex (Kasathin, 1960), and classical conditioning of sucking to a tone (Lipsitt and Kaye, 1964).

Horowitz concluded that the studies definitely indicated that the human infant is a learning organism and that there is still a great need to explore further the nature of the infant and what limits he imposes on learning. She then reviewed studies that have addressed themselves to these latter considerations. Fantz (1956, 1967, 1964), for example, has done considerable work on the perceptual abilities of infants and found that infants under 5 days of age discriminate some visual stimulation and even demonstrate "preferences" for some materials over others. While not directly involved in learning studies, Escalona (1968) has done extensive work in an effort to specify differences in infants. She used a construct of activity level to account for some differences in infants. She and a group of trained observers rated babies low, medium, or high activity over many occasions. She then arrived at general tendencies for active and inactive babies. For infants 4 to

12 weeks in age, inactive infants were more responsive in the visual modality than were active ones, and inactive babies showed more oral behavior than did active ones. Such tendencies could have implications for the infant in learning situations.

Birch et al (1962) reported stable differences in individual babies in measures such as rhythm, adaptation, threshold, and attention span. Engen (1963) reported the ability to discriminate olfactory stimuli in infants. Spears (1964) reported finding color and pattern preference in infants 4 months of age. Bower (1966) found infants have the capacity for shape constancy by 2 months. Lewis, Kagan, and Kalafat (1966) found some sex differences in patterns of fixation in infants 24 weeks of age. These and other studies have begun to define some characteristics of the human infant with regard to limits of behavior potential. The studies indicate that the infant is a more active and exploring organism with greater perceptual ability and receptivity to environmental stimuli than ever realized. The need for further work in these areas is certainly obvious.

Operant Conditioning

The review thus far presented has included only classical conditioning studies because the operant studies come out of a perspective on infant development with a different emphasis. Operant conditioning refers to a process in which the frequency of occurrence of a bit of behavior is modified by the consequences of the behavior (Skinner, 1938, 1956). Similarly, for Bijou and Baer (1961) operant conditioning involves changing the strength of a response using reinforcers as consequences of that response. As Reynolds (1968) pointed out, operant conditioning has become for some investigators an approach to psychological science. The focus of the operant approach is the study of the relationship between the behavior of an organism and its environment. One explains behavior when one can specify the conditions in the environment which produce that behavior with some reliability. To specify them, one must produce and manipulate the behavior that is to be explained. Within the operant model, behavior is designated in units called responses and the environment in units called stimuli. Responses are of two types: respondent or operant. Respondent behavior is elicited behavior and is another term for reflexive or involuntary behavior. Operants are emitted and controlled by stimuli that follow and are consequent to the behavior. Stimuli can also be described in terms of their function. There are eliciting stimuli, reinforcing stimuli, discriminative stimuli, and neutral stimuli.

According to Fitzgerald and Porges (1970), the experimental task for the operant researcher involves selection of a response class, identification of a stimulus that will affect the probability of occurrence of the operant without having strong eliciting properties for incompatible responses, and a demonstration that the behavioral change is a function of operant control as opposed to respondent control.

The operant model as applied by Bijou and Baer (1961, 1965) to developmental psychology minimizes the importance of using the terms capacity, perceptual ability, and motivation to explain behavior. Some investigators have even seen such concepts as totally unnecessary, if not detrimental, to the study of human behavior (Gewirtz, 1961; Bijou and Baer, 1965). Bijou and Baer (1965) found that operant chains were adequate as basic units for analyses of simple learning, discrimination, concept formation, and even perceptual abilities. For example, in describing perceptual behavior more specifically, the first part of the chain is "coming into contact with a discriminative stimulus" or as attending behavior. The second part of the sequence they analyze as "discriminative behavior to the stimuli controlling the behavior of the individual" or perceiving behavior. The third link is "discriminative behavior in relation to stimuli from the previous discriminative act" or reporting behavior (1965, p. 150-151).

The original definition of chaining according to Skinner (1938) stated that the response of one reflex may produce the eliciting or discriminative stimulus of another. He saw most of the reflexes of the intact organism as parts of chains. However, there are not as yet any reported studies of chaining in early infants. In fact, in his review in 1963, Lipsitt found no operant studies for infants of 4 weeks of age or younger. Bijou and Baer (1965) in their review concluded that the question of whether operant conditioning could be demonstrated in human neonates was still unanswered.

Very few operant studies have been done with older infants. Ling (1941) presented two differently shaped objects to infants from 6 to 15 months and rewarded discrimination. Brackbill (1958) reinforced the smiling response in 4-month-old infants and found that responses on an intermittent reinforcement schedule took longer to extinguish than those reinforced every time. Simmons and Lipsitt (1961) established discrimination of colored lights using an operant model for children 10 to 12 months of age.

In a more recent review Lipsitt (1967) covered several operant studies. Siqueland (1965) investigated the conditioning of head turning in infants, and Stern and Jeffrey (1965) reported the operant conditioning of nonnutritive sucking in infants. Caron (1967) manipulated the rate of the head-rotation response by contingent visual stimulation. Her results indicated that the opportunity to view heterogeneous visual patterns is reinforcing for infants who are 3½ months of age. She also suggested that conditioning procedures could be used to determine visual preferences in infancy.

Levinson and Levinson (1967) also investigated the modification of head-turning responses using visual reinforcement with 26 infants approximately 3 months of age. The infants were reinforced with a blinking light for head turning to the left or right. Increases in responses were found with reinforcement. Rovee and Rovee (1969) used conjugate reinforcement of infant exploratory behavior with 10-week-old infants in an attempt to provide a reinforcing stimulus which would sustain the attention of the infants beyond the usual 10-minute operant session. Such a schedule provides a continuously reinforcing event, the intensity of which is a direct consequence of response rate (Lindsley, 1963). They found that this schedule tripled the rate within the first 6 minutes of the 27-minute sessions; whereas, the control group who received the identical but noncontingent visual and some somesthetic stimulation did not alter in rate.

Watson (1966) was able to operantly condition his son of 3 months to fixate on an object. Once the baby learned that his eye movements could change the characteristics of the stimuli, Watson changed the contingency. The baby was required to fixate on the experimenter's left fist, then his right fist, and his left fist again. The baby learned to fixate on the appropriate hand with fewer trials with each subsequent stimulus reversal. Watson's impression was that there was generalization from one contingency to the next and possibly even to other situations. He only had one subject, and the experiment was not tightly controlled, but it provoked some interesting questions. For example, does such an arbitrary manipulation of behavior that is programmed earlier than it would usually occur in the natural development of the infant have any lasting impact on the infant? Does it generalize beyond the specific stimuli used to establish or maintain the response?

It is to these kinds of questions that the present study is directed. The study was planned to extend some of the recent work in infant developmental research. A recent position taken by Fantz (1967) in an article that summarized his own research and perspective raised some of the theoretical issues in this area. He took the position that the old nativism-empiricism controversy which was replaced by a more sophisticated interactionism with different emphases is really an insoluble question. Rather, Fantz suggested that it is more likely that there are two kinds of learning processes and that both are important for the understanding of human behavior. The different types of learning he refers to are the change in response tendency and the acquisition of knowledge apart from specific changes in response. His acquisition of knowledge would involve perceptual and conceptual processes which organize information for the individual. Fantz believed that the efforts should now be directed to "isolating specific effects of environmental influences or the lack of such influences on the initial unlearned behaviors and, at the theoretical level, to try to distinguish between fundamentally different types of learning or effects of experience" (p. 187).

More specifically, there were three areas of interest that provided a framework for this study. The first area or purpose was to further investigate some aspects of operant conditioning procedures with young babies, that is to investigate changes in response rate. Although the research in the area is still scanty, the operant procedure seems to offer promise as a methodology for infant study and developmental problems. An illustrative study was that of Sheppard (1969) who established differential responding under discriminative control in two concurrent responses (vocalization and leg kick) in his infant who was 10 days old at the beginning of the study. The study was aimed at demonstrating operant control over motor and vocal behavior. The present study carried his procedures to one of several possible next steps, chaining. A chain is established when the response produces a stimulus which is reinforcing for that response and discriminative for the next one in the chain, until a terminal primary reinforcement is produced (Kelleher, 1966; Kelleher and Gollub, 1962).

The second purpose of the study was to look at what role the stimuli play in obtaining the conditioning effects. The study attempted to specify what relevance the learning had for the infant. Watson (1966) proposed that early experience with contingencies may program the infant to be ready to process his experience in similar ways. Fantz has found preferences for certain visual stimuli at very early ages and tendencies toward different preferences at different ages. Because infants attend selectively to parts of the environment, Fantz holds that the "acquisition of knowledge begins at the first look" (1967, p. 187). Such selective attention gives the infant differential exposure to his environment. This kind of familiarization process provides a base on which all subsequent learned or conditioned behavior will be established. He thinks that the learning defined by the behaviorists can specify the strength of response tendencies to different stimuli but does not clarify whether the information facilitates perceptual development and familiarization with the environment. If the infant is involved in a process that is educational as well as reinforcing, his experience with certain stimuli should not only determine to some extent his ability to cope with these same stimuli at another time, but will also determine to some extent his way of processing other information or stimuli in the environment. If such experience is educational, there should be some "generalization" effects, and these should be measurable.

A third purpose was to examine closely the separate components of the learning process, namely, the babies and the stimuli. Since the operant method lends itself so well to the study of individual differences (Sidman, 1960), this study provided an opportunity to follow up on some related work.

First was a study done by Koch (1968) who manipulated the kinds of stimuli used in a conditioning study to determine which stimuli were most reinforcing to babies at different ages. He conditioned oriented head turning in babies 2 to 5 months of age. He used 4 different stimuli and found that a stimulus known from other natural situations, for example, the mother, but always used in the experimental situation in the same manner as a reinforcer had a poor reinforcing effect. He made the point that the mother was less reinforcing than either a stranger or a novel stimulus only within the experimental situation.

That is, once out of the experimental situation, the infant began to respond to his mother again.

Sheppard (1969) also changed reinforcers and tried various combinations of reinforcers in his study but was not able to tell whether or not age of the infant was interacting with the different stimuli. This study used different stimuli for different babies but the same throughout the conditioning. An attempt was made to measure changes in response rate to the same and to different stimuli as the context changed from the experimental to the natural environment.

One variable which may interact with stimuli in a differential way is the sex of the infant. Sex differences have been well documented for babies of one year or more, but many of the early infant studies do not even report the sex of the subjects. Lewis, Kagan, and Kalafat (1966) reported some sex differences in patterns of fixation in infants 24 weeks of age. Kagan and Lewis (1965) found sex differences in attention to auditory stimuli in infants 12 weeks of age. Watson (1969) found an interaction effect between sex and reinforcement modality in babies 10 and 14 weeks of age. He operantly conditioned visual fixation with contingent visual and auditory stimulation. He found evidence to suggest that females learned under visual but not auditory stimulation, and males learned under visual but not auditory stimulation at 14 weeks. At 10 weeks the same held for females, but males did not learn under either condition.

Rheingold, Gewirtz, and Ross (1959) and later Weisberg (1963) examined vocalization behavior in 3-month-old infants in institutions. While Rheingold, Gewirtz, and Ross increased the rate of vocalization, they did not separate the eliciting from the reinforcing function of the stimuli. Weisberg replicated their study but added a noncontingent reinforcement group of infants who received the "social" stimulation but never directly after vocalization. The reinforcement consisted of a smile, a light touch on the abdomen, and a "tsk" sound. He concluded that the human presence alone did not increase the vocalization rate and that contingent reinforcement was necessary.

Work done by Escalona (1968) concerning the infant's activity level suggests that infants can be described along a continuum ranging from active to inactive with most babies falling somewhere in the middle. Escalona has developed measures which permit babies to be rated on such characteristics as their responsiveness to external and internal stimuli. It may be hypothesized that babies with different activity scale ratings would demonstrate different conditioning rates in terms of time and quality of the stimuli involved. Basal activity data obtained prior to conditioning offer an opportunity to determine specifically how individual differences in activity may be related to the effectiveness of operant procedures and establishment of a behavioral chain.

In summary, while the experiment to be presented had to be somewhat specific in order to be manageable, the study was undertaken in an effort to integrate previous data and questions from several areas in developmental psychology.

CHAPTER II

METHOD

Subjects

There were 5 subjects (Ss) in the experiment. Four of these, 2 males and 2 females, served as experimental Ss. One, a female, served as a control subject. All 5 were full-term babies whose deliveries were normal. None of the mothers had experienced any major difficulty with pregnancy, and none of the babies had experienced any serious illness. Their average age was 70 days at the beginning of the study.

Apparatus

Most of the initial baselines and all the conditioning sessions involved having the S propped in his own infant carrier. All sessions were held in the respective homes in the same place each time and in a place of the mother's choosing: the floor, on a couch, or on a table. For the chaining sessions, a curtain was devised by hanging two wide strips of sheeting on a 24-inch wire suspended between two dowels 5 feet tall. All appropriate responses were recorded manually by the experimenter (E) on an Esterline Angus event recorder set at a speed of .75. At the start of the study a voice-operated relay was attached to the event recorder to give a mechanically controlled response count.

This proved to be useless as the apparatus could not distinguish vocalizations from sneezes, hiccups, et cetera, or from the vocalizations of other persons in the room.

A facial vibrator was used for tactile stimulation with the first 2 Ss but was omitted for the others as it was noisy and awkward. It was replaced by the mother's hand. The stimuli presented to the Ss included mother's face, E's face, a brightly colored Halloween mask, and a two-dimensional cardboard face with eyebrows, eyes, nose, mouth drawn on to resemble a human face in perspective and proportion. The potentially reinforcing event consisted of mother's repeating a simple, several syllable statement that seemed natural to her, such as "That's a good baby" while she applied tactile stimulation to one or other leg of the infant.

Procedure

The E arranged with each mother each day to run a session at a time that was convenient for both E and mother and that was also a time when baby was not particularly hungry, sleepy, or fussy. As the schedules of all three of these persons were variable, each baby experienced sessions at several times of the day. As much as possible sessions were run every day, although occasionally circumstances made that impossible. Sessions seldom lasted more than 15 minutes, and there were several occasions when they had to be terminated sooner when the Ss became fussy. Infants at this age have relatively short periods of alertness and usually show signs of fatigue much beyond 15 minutes. The average number of sessions for each experimental S was 17.

Baselines

Before conditioning six baseline vocalization measures were taken on all 5 *Ss* over 3 or 4 days. Each baseline was 5 minutes in length and included the following conditions: (1) mother within *S*'s visual field, unresponsive; (2) mother within visual field, responsive naturally; (3) *E* within visual field, responsive naturally; (4) mask presented with no reinforcement; (5) flat face presented with no reinforcement; (6) some other location such as a crib, playpen, or stroller. Baselines were short to allow for two or three to be taken each day and to prevent the *Ss* from becoming familiar with those stimuli that were novel to them.

Activity level

During the days when Baseline I was being recorded, the *E* observed and assigned activity measures for each of the *Ss* under 5 conditions. Using criteria similar to Escalona (1968), activity level was rated on a three-point scale: 1 = Relatively small amount of activity, often of low intensity; 2 = Medium amount of activity, that is, behavior neither conspicuously active or inactive; 3 = Large amounts of activity, often forceful. Ratings were given for activity level (1) when an object was offered *S*; (2) when *S* was smiled at, touched, and talked to by stranger (*E*); (3) when *S* was in infant seat, mother near but not attending; (4) when *S* was in crib or playpen with mobile or toys; (5) when *S* smiled at and talked to by mother.

Conditioning

The conditioning procedure involved reinforcing the *Ss*' vocalizations with auditory and tactile stimulation on a continuous reinforcement (crf)[1] schedule. For 2 Ss the discriminative stimulus (S^D)[2] during conditioning was their own mother's face. For the other 2 the S^D was the mask. Tracy was the first S and different in that she was put on a fixed-ratio 3 (FR 3)[3] reinforcement schedule during the sixth session. Fixed-ratio schedules usually produce consistently higher rates of responding than crf. The E was only allowed for 4 FR 3 sessions, and the change in Tracy's overall performance was not outstanding enough to make it seem worthwhile to use this extra step with the other Ss. There was seldom any problem with the Ss not attending to the stimuli. Occasionally, when a S looked away from the S^D, mother simply moved into the S's visual field.

Chaining

After several sessions and some increase in the rate of vocalization, chaining was initiated. This procedure involved placing the curtain apparatus between the S and his mother in such a way that she was still the approximately same distance (18 inches) away as she had been in conditioning but hidden from view. E observed both from a place that was visible to mother but out of the S's visual field. Mother remained hidden until signaled by the E that S had made a leg kick. At the signal mother parted the curtains and came into view for the S. She remained unresponsive until S vocalized at which time she applied the reinforcement and then went behind the curtain. Thus the leg kick response produced the appearance of mother's face or mask which in turn served as a discriminative stimulus for the vocalization response which in turn produced the tactile stimulation and mother's voice.

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[1] Continuous reinforcement (crf) schedule indicates that reinforcement follows every appropriate response.

[2] Discriminative stimulus (S^D) is one which sets the occasion for a response which is to be reinforced.

[3] A fixed ratio schedule indicates that reinforcement follows every third appropriate response.

Baseline II

After the chaining sessions, the original 6 measures were again taken over 2 or 3 days. The Ss were given 5 minutes of crf conditioning before baseline measures were taken in an attempt to minimize the possible effects of extinction. The 6 baseline measures were also taken on the control S 2 weeks after the original measures.

CHAPTER III

RESULTS

Activity Level

The average activity rating for each of the 5 Ss was as follows: Tracy = 1.0; Brent = 2.0; David = 2.4; Michele = 1.6; Lisa = 1.2. See Appendix A for details. Both males were more active than the females. Comparing overall activity ratings with Baseline I, it appeared that Ss with the lower activity levels also have lower rates of vocalization before conditioning. After conditioning the trend is less consistent. See Table 1. Brent's, Michele's, and David's average rates of vocalization are higher after conditioning and still reflect activity levels relative to each other. The exception to the trend was Tracy, who had the lowest activity rating and relatively low baselines, but who had the highest average Baseline II rating after conditioning.

Lisa, who served as a control, received no conditioning or chaining experience. After an interval of two weeks, she had a higher rate of vocalization to mother than previously, but all her other baselines were lower.

To determine whether activity level facilitated or interfered with conditioning, activity level was compared to conditioning performance. Both average rates of vocalization and change in rates during conditioning

Table 1

Baselines I, II Vocalization Rates per Minute[1]

Subject	Activity Level	Baseline	Mom/ Quiet	Mom/ Natural	E/ Natural	Mask	Other Place	Flat Face
Tracy	1.0	I	1.17	1.50	1.57	3.40	2.00	2.60
		II	6.00	19.20	5.80	8.40	3.80	7.80
Brent	2.0	I	6.38	4.40	8.00	5.40	6.00	1.80
		II	5.80	3.00	8.80	5.00	8.80	8.40
Michele	1.6	I	0.80	1.20	3.40	1.33	5.00	0.40
		II	4.00	4.00	4.20	2.1*	3.75	1.40
David	2.4	I	6.60	6.40	5.40	4.00	3.25	5.40
		II	3.60	11.60	6.00	4.50*	6.00	3.00
Lisa**	1.2	I	3.80	2.00	4.80	2.20	2.60	2.60
		II	1.80	6.20	0.60	0.60	1.80	1.40

[1] All rates reported in this paper indicate rates per minute.

*These rates are an average of the 2 crf measures taken just prior to Baseline II rather than extinction measures.

**Control subject.

were examined. These rates are reported in Table 2. The range reflects the lowest and highest rates of vocalization recorded during the conditioning sessions. They are not necessarily the first and last sessions' rates. There is no obvious consistent relationship between activity level and performance during conditioning across _Ss_. However, David had the highest activity rating and the lowest average conditioning session length. For this _S_ the activity rating in part reflects his restlessness and difficulty staying in any place for more than a few minutes.

To determine whether activity level facilitated or interfered with chaining, activity level was compared to chaining performance. Average rates of vocalization and change in rate during chaining were examined. These rates are presented in Table 3. Again there was no obvious consistent relationship between activity level and performance during chaining. Vocalization rates were higher during chaining than during conditioning for all _Ss_. Three of the _Ss_ had longer sessions during chaining than during conditioning.

Vocalization rates during conditioning and chaining were based only on vocalizations made in the presence of the S^D. While there were some vocalizations at other times, these would have been a very small percentage of the total number of responses.

Stimulus Differences

The use of 2 different discriminative stimuli (S^D) provided another variable to be examined. Two _Ss_, Tracy and Brent, were presented their own mother's face as S^Ds. Michele and David were presented masks. The data

Table 2

Vocalization Rates During Conditioning

Subjects	Activity Level	Range of Rate	Average Rate	Average Min./Session	Total Time
Tracy	1.0	1.35 - 8.08	4.18	13.44	111 min.
Brent	2.0	4.21 - 7.30	5.29	14.25	57 min.
Michele	1.6	0.80 - 3.00	1.83	11.00	66 min.
David	2.4	2.00 - 5.80	3.85	6.80	40 min.

Table 3

Vocalization and Leg Kick Response Rates During Chaining

Subject	Activity Level	Range of Vocalization Rates	Average Vocalization Rates	Range of Leg Kick Rates	Average Leg Kick Rates	Average Min./Session	Total Time
Tracy	1.0	2.11 - 7.36	5.17	2.05 - 4.17	2.69	14.20	71 min.
Brent	2.0	4.41 - 9.72	7.71	2.47 - 7.29	3.94	13.75	110 min.
Michele	1.6	1.55 - 6.25	4.08	2.37 - 5.51	3.66	14.20	71 min.
David	2.4	2.92 - 9.79	5.95	0.91 - 3.57	2.11	12.67	76 min.

of each pair were combined in order to compare their performances during conditioning under different stimulus conditions. The combined data are presented in Table 4. The 2 Ss who had mother as S^D had a higher average rate of vocalization during conditioning, and they reached a higher rate than did the Ss who had the mask as S^D. The average rate of vocalization during the first conditioning session was slightly higher for the Ss who had the mask. However, the mother Ss had a considerably longer total time. Taking only Tracy's first four conditioning session rates to make the total time equivalent, that is, 108 minutes for Tracy and Brent as compared to 106 minutes for David and Michele, the average rate for the mother Ss was 3.71 as compared to a rate of 2.84 for the mask Ss.

The data were again combined to compare the mother Ss' performances during chaining with that of the mask Ss. These data are reported in Table 5. The rates of vocalization were higher across all measures for the mother Ss. Once again in order to make the total time comparable, Brent's last three measures during chaining were dropped, leaving Brent and Tracy with a total time of 143 minutes. Their average vocalization rate was still slightly higher at 6.29 than David's and Michele's rate of 5.01.

Baselines I and II were re-examined with the focus on stimulus differences this time. Table 6 indicates the order of rates of vocalization from lowest rate (1) to highest rate (6) before and after conditioning. Before conditioning Tracy was most vocal in the presence of artificial stimuli and more vocal with unfamiliar than familiar stimuli. After conditioning with mother as S^D, she was much more vocal with mother, but she still had high rates to the mask and flat face.

Table 4

Averaged Vocalization Rates During Conditioning

S^D	Average Rate	Rate of First Session	Best Rate	No. Vocal.	Total Time
Mother	4.04	3.00	7.69	788	168 min.
Mask	2.84	3.73	4.40	252	106 min.

Table 5

Averaged Vocalization Rates During Chaining

S^D	Average Rate	Rate of First Session	Best Rate	No. Vocal.	Total Time
Mother	6.44	5.37	8.54	356	181 min.
Mask	5.01	3.57	8.02	235	147 min.

Table 6

Ordering of Baselines*

Subject	Baseline	Mom/ Quiet	Mom/ Natural	E/ Natural	Mask	Other Place	Flat Face
Tracy	I	1	2	3	6	4	5
	II	3	6	2	5	1	4
Brent	I	4	2	6	3	5	1
	II	3	1	5	2	5	4
Michele	I	2	3	5	4	6	1
	II	4	5	6	2	3	1
David	I	6	5	3	2	1	3
	II	2	6	4	3	4	1

* Lowest rates (1) to highest rates (6) on Baselines I, II.

Tracy was the only S who showed an increase in vocalization rate across all measures. Her average baseline rate before conditioning was 2.04 and after was 8.50.

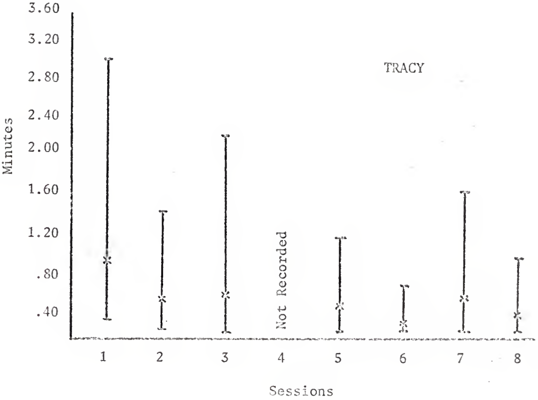
Brent was most vocal in the presence of E before conditioning, and his lowest rate was to flat face. After conditioning with mother as S^D, Brent was much more responsive to flat face than before and had slightly lower rates to mother than before conditioning. Brent had an average vocalization rate across baselines before conditioning of 5.43. After conditioning his average rate was 6.63.

Michele was most vocal before conditioning in the presence of her mobile and with E, an unfamiliar person. After conditioning with the mask, Michele was more vocal with mother and less with her mobile. Her vocalization rate to the mask was higher after conditioning, but it dropped from third highest to fifth. She had an average vocalization rate across Baseline I of 2.02. After conditioning her average rate had increased to 3.24.

David was most vocal with mother before conditioning. After conditioning with the mask as S^D, David was less vocal when mother was unresponsive than he had been before and more vocal to his toys and to mother when she was responsive. His rate to the mask was only slightly greater after conditioning, and his average rate across Baseline I was 5.18 and across Baseline II was 5.78.

Conditioning

The following graphs (Figures 1, 2) demonstrate the changes that occurred during the conditioning phase for each S. Tracy obtained a rate of 1.47 vocalizations per minute during her first crf session.



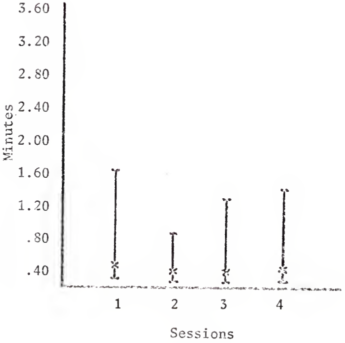


Figure 1. Range and Average Vocalization Latencies During Conditioning Across Sessions for Tracy and Brent.

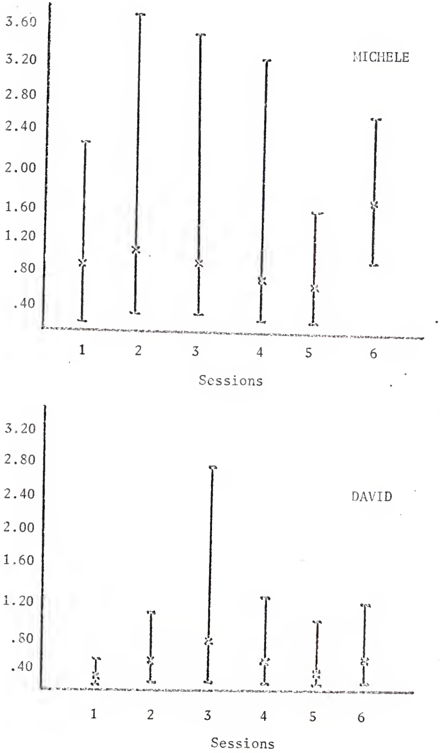


Figure 2. Range and Average Vocalization Latencies During Conditioning Across Sessions for Michele and David.

She had nine sessions and 111 minutes of conditioning. Her peak rate of 8.08 was obtained during the seventh session of conditioning. Tracy had a pattern of dropping in rate below the previous session's rate every other session but with an overall trend of increasing rate. Tracy not only achieved the highest rate of vocalization, but she also showed the most dramatic increase in her rates going from a rate of 1.47 to a rate of 5.62 on the ninth session. The session by session rates for Tracy and the other 3 Ss are presented in Figures 3 and 4.

Brent started with a rate of 4.53 on the first day of conditioning, reached a peak on the second day of 7.30 and then dropped back to a rate of 4.21 on the fourth day. He had four sessions and 57 minutes of conditioning.

Michele started with a rate of 1.71 during her first conditioning session. She peaked at a rate of 3.0 during her fourth session and then dropped down to a rate of 0.80 during the sixth session. The sixth session rate was not taken under the appropriate conditions since Michele was fatigued and the session had to be terminated early. She had 6 sessions and 66 minutes of conditioning.

David started with a rate of 5.75 on the first day of conditioning dropped down to a rate of 2.00 on the third, and then was back up to a 5.80 during the fifth. One difficulty with David was his irritability. He had six sessions, but only 40 minutes of total time in conditioning.

Examining the data in the conditioning phase alone, the results suggest that the vocalization rates of Tracy and Michele were under control of reinforcement. Brent's and David's data were equivocal.

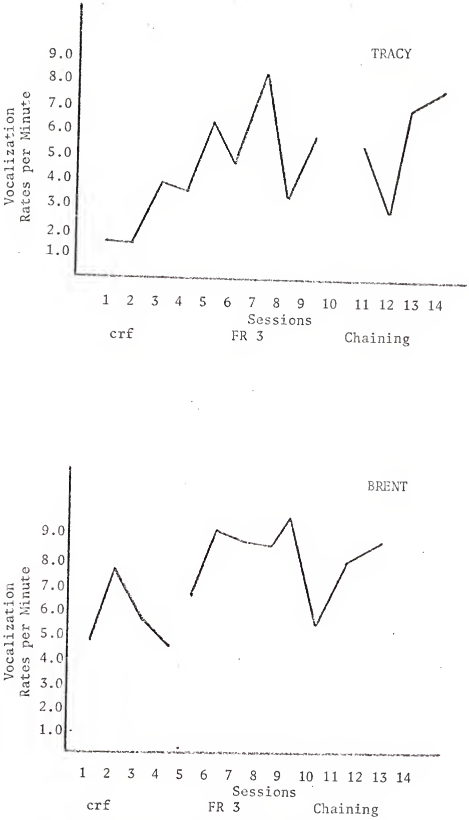
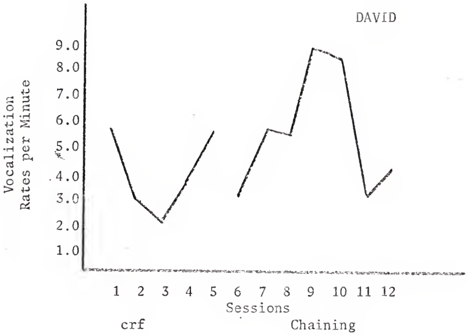


Figure 3. Vocalization Rates per Minute Across Conditioning and Chaining Sessions for Tracy and Brent.



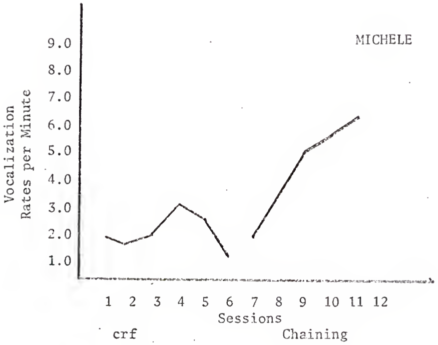
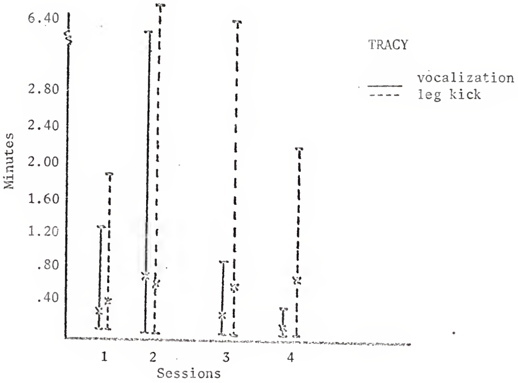


Figure 4. Vocalization Rates per Minute Across Conditioning and Chaining Sessions for David and Michele.

Chaining

Vocalization rates during chaining were usually significantly higher for each Ss than during conditioning. The vocalization and leg kick latencies across sessions for each S are presented in Figures 5 and 6. The leg kick and vocalization rates across sessions for each Ss are presented in Figures 7 and 8. The strongest evidence for chaining is in the change in the leg kick rate across sessions, and the data suggest chaining occurred for Brent, David, and Michele. Tracy had only 4 sessions and her data are equivocal.

Tracy had 5 chaining sessions and 71 minutes, and her best vocalization rate was 7.36. Brent had 8 sessions, 110 minutes, and climbed to a vocalization rate of 9.72. Michele had 5 sessions, 71 minutes, and her best vocalization rate was 6.25. See Appendix B for complete details on rates in both conditioning and chaining. All Ss achieved vocalization rates well above baseline by the end of the chaining sessions.



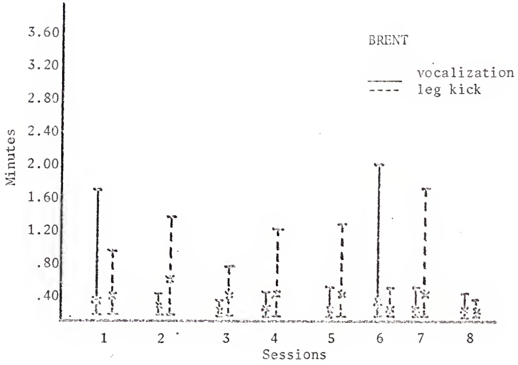


Figure 5. Range and Average Vocalization and Leg Kick Latencies During Chaining Across Sessions for Tracy and Brent.

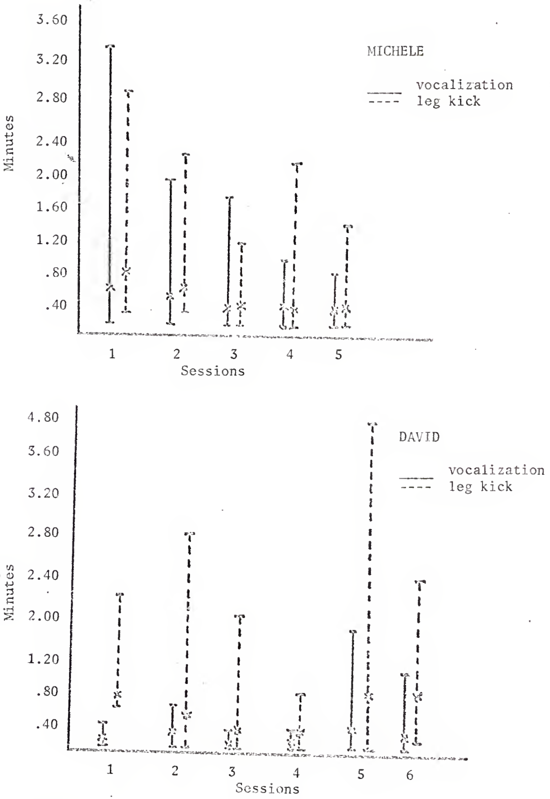


Figure 6. Range and Average Vocalization and Leg Kick Latencies During Chaining Across Sessions for Michele and David.

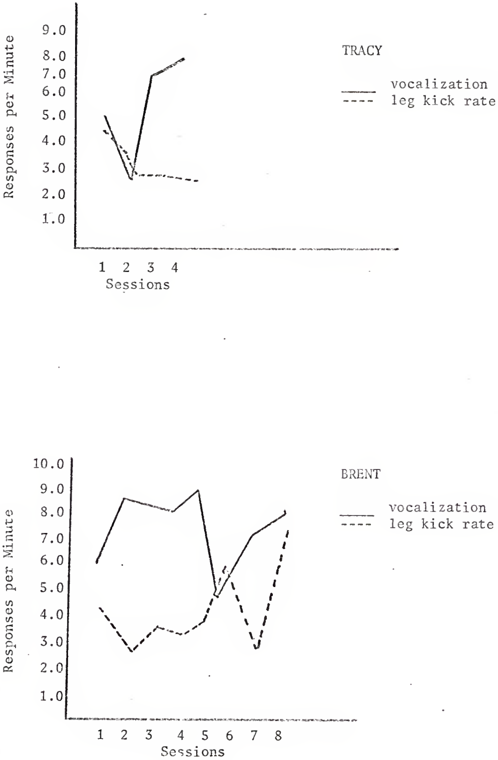


Figure 7. Vocalization and Leg Kick Rates Across Chaining Sessions for Tracy and Brent.

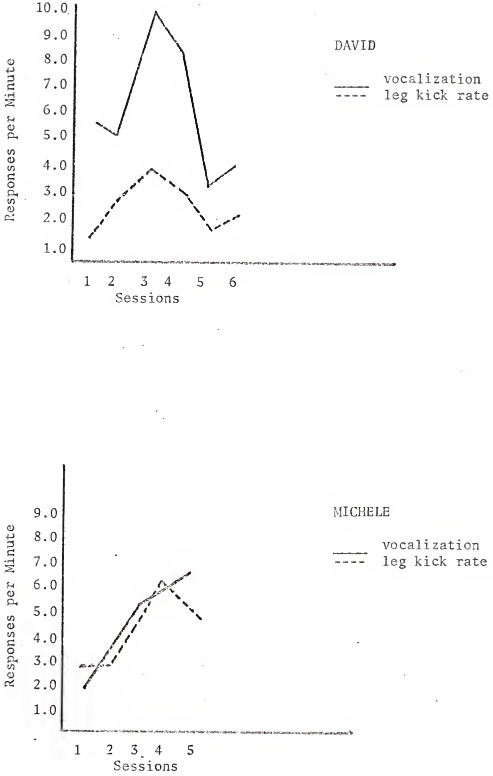


Figure 8. Vocalization and Leg Kick Rates Across Chaining Sessions for Michele and David.

CHAPTER IV

DISCUSSION

Chaining

A major finding of this study is that it is possible to establish at least a two-component chain of behavior in a 2-month-old infant. Until now this has not been reported in the literature with infants as young as 2 months. Skinner (1938; 1956) suggested the importance of chaining as a basic process of most complex human behavior. Bijou and Baer (1965) are similarly inclined in their theory of child development.

All 4 Ss demonstrated some change in their patterns of performance during the chaining sessions both from first to last session and during individual sessions. Brent's performance was the most outstanding, and he came close in his last session to a maximum possible rate. Chaining can be understood as extending the conditioning procedure another step; that is, once the vocalization sequence was established, shaping and conditioning of the next link, the leg kick followed. Assuming that some conditioning had taken place, one would expect greater variability in the leg kick response rate during chaining. This was the typical pattern for Brent. There were very few occasions when his vocalization rate tended to be much more stable. However, his leg kick rate increased sufficiently to suggest chaining occurred. Similarly, the data suggested chaining occurred for Michele and David as well. Tracy's data were equivocal. The amount of time spent in chaining sessions was the most important variable in understanding the differences in performances among the 4 Ss of this study. Brent achieved the highest average rate of vocalization and also had the most stable rate, and he had the longest total time in chaining. None of the babies either in conditioning or chaining showed a steady increase in rate each day. There was considerable fluctuation in rate which suggests the need for more sessions.

There were reasons for the limits placed on the number of sessions. One came out of the scheduling difficulties. It was E's desire to keep the total number of sessions below three weeks in an effort to minimize the inconvenience to the Ss' mothers. The E also wanted to finish the sessions before any S became 3 months of age. Three months has often been considered an important age developmentally and has often been the minimum age at which operant conditioning has been attempted by investigators in infant research. Had the study extended into what may be a critical period developmentally, it would have been difficult to interpret the results. Further, the E wanted to avoid one of the difficulties of Sheppard's (1969) work. His study covered such a period of time, and the infant develops so rapidly in the first few months, that it was not clear that observations made late in the study would have been the same earlier and vice versa. Lastly, the decisions to move from one phase of the study to another were partly a function of the S himself. For example, in retrospect, Brent should have received more than 4 conditioning sessions. However, his best rate was during the second session, and when he dropped considerably during the third and fourth, the E decided to move on to chaining before the rate dropped further. This kind of fluctuation in rate of responding is typical of the infant, and the variables influencing the infant's behavior do not have the stability found in the adult.

Both the mothers and E observed that Brent, David, and Michele were more "interested in" or attentive and responsive during chaining than conditioning. David and Michele maintained responding for longer sessions than they had previously in conditioning. All the Ss reached higher rates of vocalization during chaining and conditioning. In operant terms, this may be an example of a phenomenon originally named by Skinner (1938) called behavioral contrast. Reynolds (1961) has observed and described this phenomenon as occurring during discrimination training. Often after discrimination training is initiated and the rate of responding in the absence of the S^D begins to drop, the rate in the presence of the S^D goes up. Unfortunately, the vocalizations in the absence of the S^D were not recorded, but the procedure during chaining resembles discrimination training as the S^D is not always present as it is during conditioning.

Conditioning

A significant implication of this study is the extent to which an infant of two months is responsive to stimuli in his environment. In behavioral terms, a change in behavior in the 2-month old is possible with relatively little exposure to conditioning. It is not only that a rate change has been accomplished, what is also important is that the interaction between the infant and his world has been altered in the direction of a more active involvement with his experience. How far reaching or permanent a change this can be has yet to be answered.

As with chaining the most critical variable with respect to conditioning performance was the total conditioning time. Tracy had the highest peak rate and the most total time in conditioning. It was very difficult to compare performances since all the Ss had a different total conditioning time. In retrospect a change in procedure might have reduced the difficulty; E could arrange the sessions so that all Ss could have approximately the same total times in both conditioning and chaining. This would have made it easier to examine the other variables which contribute to the changes in vocalization rates. The rates reported reflect only the vocalizations that occurred in the presence of the S^D, rather than all vocalizations. There were not many inappropriate or additional vocalizations, but future studies should provide for recording all relevant responses. Another variable which is probably relevant is the schedule of reinforcement (Ferster and Skinner, 1957). Behavior which is already at a fairly high rate before conditioning is often difficult to manipulate on a crf schedule (Skinner and Morse, 1957). This may have been the problem with Brent and David during the early conditioning phase, since they both had high vocalization rates at baseline.

Stimulus Differences

In comparing the different S^Ds used in the study, it was found that the rates of vocalization to mother's face were slightly higher than those to the mask during and after conditioning. Even though the

Ss were selected and assigned conditions before activity measures were taken, the 4 Ss were well matched in activity rating and average baseline performance. One hypothesis then to explain this difference is that mother's face was more reinforcing than the mask. This would be contrary to the findings of Koch (1968), who found that mother was least reinforcing. However, in Koch's study, mother's face was a reinforcer; whereas, in the present study, mother's face was a discriminative stimulus primarily. The situation in this experiment more closely resembled the natural situation than did Koch's experimental situation. It was the unnaturalness that he thought accounted for the discrepancy of his findings.

However, both Tracy and Michele had higher Baseline I rates to the mask and to the E than to their own mothers. This finding would suggest that some relationship between the S and the stimuli such as novelty might be important. Another possibility is that these differences in baselines also reflect differences in these infants' histories of interactions with mother and also in activity level. None of these Ss had any history of experience with the mask, but they all had considerable experience with their mothers' faces. The E's observations would suggest the histories may be different in a way that is significant to the results of this study.

The first observation was that both Tracy's and Michele's mothers talked more at the S than with the S in the natural situation. That is, while they both attended to the Ss and talked to them, these two mothers talked with little expectation of responses from the Ss. In behavioral terms the mother's responses were not contingent on the infant's responses. These two babies were also less vocal across conditions than the other two Ss. That is, their activity ratings would suggest they would be less responsive. Brent and David had higher activity ratings across baselines and had mothers who acted with the expectation that their babies would respond. In fact, at times it seemed as if Brent and David vocalized in an attempt to elicit mother's response rather than the other way around, as was the case with Michele and Tracy. It would be interesting to try to take into account the nature of the mother-infant interaction with regard to vocalization and other behaviors before intervening with conditioning or other procedures in order to understand whether the intervention is essentially an extension of or a change from the natural interaction. In this study the observations suggest that the conditioning procedure was more of a change in interaction for Michele and Tracy and more of an extension for Brent and David. Tracy and Michele also showed larger increases in rate of vocalization to their mothers after conditioning, even though Tracy had mother as an S^D and Michele had the mask as an S^D.

The boys' data were less consistent. Brent actually lost some ground with mother in Baseline II taken after conditioning, and David, who had the mask as S^D, showed a decrease in rate to mother/quiet. With Brent one hypothesis is that his performance reflected a ceiling effect. That is, at one point in his interaction with a particular stimuli, some other stimuli or variables begin to interfere. One recalls that his vocalization rate declined during the third and fourth conditioning sessions. David received the least experience with conditioning of all the babies, but enough to reinforce the expectation of interaction with stimuli. That is, the only two measures for which he had lower Baseline II rates were mother/quiet and flat face. These were the only two for which there was no change in the stimuli while

David was vocalizing. This finding is consistent with his activity rating which described him as a baby who is very attentive to and responsive to stimulation in his environment.

At this point it is not clear how to predict how the effects of conditioning and chaining will generalize in any simple way across babies. There appeared to be some generalization with all Ss, and both the stimuli used in conditioning and the history of the baby probably determine the unique pattern for each infant.

Activity Level

One factor is indicated by the activity rating. As was clear in the result section, the activity level does have an important role in the understanding of the performances of the Ss in this study. The babies with the higher activity ratings had higher baselines of vocalization before conditioning. While there was some consistency after conditioning, the impact of conditioning needs to be emphasized. Tracy had the lowest activity rating and ended up with the best conditioning performance, and the fact that she had the most experience in conditioning probably explains this correlation. Activity level was of importance in David's case because it reflected his irritability and difficulty handling more than a few minutes of conditioning at any one time. In retrospect E might have avoided this difficulty by programming 2 short sessions per day to give David a comparable amount of exposure to the experimental procedure over the same amount of time.

In this sample of 5 Ss, the 3 females fell closer to the inactive end on the activity rating scale and the 2 males by comparison toward the active end. For this sample, then, there were sex differences. In her work with activity level, Escalona (1968) had more male active babies and more female inactive babies in her much larger sample, but there were many exceptions. In view of this finding and because the present sample is small, the differences have been described as differences in activity ratings rather than sex. Ordinal position among siblings was checked, but, again without intention on the E's part, this factor was balanced by activity ratings. Tracy and Brent were first-borns, and Michele and David had one and three siblings, respectively.

While the activity ratings of this study are similar to Escalona's, they are limited. Escalona used trained raters and observed each infant in over 5 dozen situations. The E was the only rater in this study, and only 5 measures, one of which was not discriminating, were used. All 5 Ss scored 1 when offered an object by the E. The ratings do reflect relative activity ratings among the Ss of this sample, and all observations were made before conditioning in order to avoid experimenter bias.

In conclusion an interactional model seems necessary to account for the relevant variables. For example, Escalona (1968) suggested that activity level could facilitate or interfere with the learning experiences of the infant and further that the effects could be modified or exaggerated by the mother's expectations. Stimulus characteristics need to be accounted for, although more work is still necessary to understand how these characteristics relate more specifically to learning. Finally, there are principles of conditioning and chaining that are relevant to the infant's performance. These have just begun to be investigated in infants.

An Integrative View of Early Infant Development

There is also a need in developmental research for frameworks which attempt to integrate the data. The preceding discussion was described in operant or behavioral terms. Piaget has offered an integrative framework which is relevant to this discussion. For Piaget the infant's development would be included in the sensory-motor period. During this period the infant advances from a self-oriented, reflex level of behavior to a gradually more complex and organized level of sensory-motor actions that are environmentally oriented. This period he divided into 6 major stages. Three are relevant to the present study. Stage 1 is characterized by the use of reflexes and includes roughly the first month of the infant's life.

Stage 2 is characterized by the first acquired adaptations and primary circular reactions. It covers roughly months 1 through 4. At this stage the simple reflexes are elaborated into the first simple habits, for example, systematic thumb-sucking. As Flavell (1963) described Piaget's concept of primary circular reaction, it refers to a repetition or series of repetitions of a sensory-motor response. The initial response is new in that its results are not anticipated, but the importance of the reaction is in that the infant tends to repeat the new adaptation until it becomes a firmly established schema. An example of a primary circular reaction would be in an infant's elaborating and prolonging crying which comes at first out of frustration but which is prolonged because it is an interesting sound.

Stage 3 is characterized by secondary circular reactions and procedures for making interesting sights last. It includes roughly ages 4 through 8 months. Secondary circular reactions are similar to primary ones in that they consist of the repetition of chance patterns or adaptations. One difference, however, is that while the infant in Stage 2 is more interested in his bodily activities, the infant in Stage 3 is more interested in the environmental consequences of his behavior. An example of this kind of pattern is found in the infant who finds out his mobile moves when he kicks his leg, and he continues to kick in order to move the mobile. This raises the issue of intentionality, and for Piaget, Stage 3 is a transition period between the occurrence of non-intentional behavior and the appearance of intentional, goal-directed behavior. Flavell (1963) described a behavior sequence as intentional the more it is directed outward toward object, the more intervening instrumental acts involved, and the more obviously it is a forward-looking adaptation to the new. Thus, Stage 3 is semi-intentional because it is directed toward the environment. The limitation is in how the intentionality comes about. In later stages the infant begins a sequence with a goal and looks for the means to accomplish it. In secondary circular reactions, the interesting sensory event becomes a goal only after the means have been put into effect.

The findings of this study when examined in the Piagetan framework suggest that these babies performed into Stage 3 and that movement from one stage to another may be facilitated artifically. At the beginning of the study vocalizations for these infants would be considered to fluctuate between primary and secondary circular reactions. At times the vocalizations were primary in the sense of being simple and coming from the infant and not being connected to or coordinated with any visual pattern, for example, focusing on any particular stimulus. During conditioning the vocalizations do become connected with external objects and with repetition a pattern or schema becomes stabilized. This pattern is then an instance of a class of relations "to vocalize-to-hear-mother," and it qualifies as a secondary circular reaction. The infant is not vocalizing for the sake of vocalizing but in an attempt to make something happen, to make mother vocalize. His interest in the consequences of his activities places him in the third stage of development. It would be impossible to distinguish with each vocalization whether it was primary or secondary. However, the variation in rates of vocalizations during sessions and across sessions suggests a combination. Further, the E observed differences in the infants' vocalizations on occasions which suggested both patterns. As was mentioned earlier, Brent appeared to try to elicit vocalizations from his mother more often than Tracy even before conditioning.

The chaining sequence is another example of a secondary circular reaction. There was very little leg kicking behavior for these infants in their infant seats during the conditioning, but after a few kicks during the chaining sessions, the infants would often seem "to catch on." They would kick in order to make mother/mask appear, and then vocalize in order to hear mother's voice and to get rubbed. The sequence is object-oriented and with repetition becomes goal-oriented. It was Piaget's impressions that the activity itself as well as the goal was rewarding to the infant. In this study the Ss seemed much more interested and eager during the chaining than they did during conditioning. The length of their chaining sessions tended to be longer as well. While the terminal reinforcement is the same in each case and the sequence in both conditioning and chaining develops into secondary circular reactions, the sequence in chaining is more complicated, and the leg kick component is clearly a new schema for all these infants.

The approximate ages for the third stage of development were projected for 4 to 8 months. The infants in this study were 2 months, considerably younger. White (1969) found evidence in his study of infants 1 to 6 months that providing some of the infants with enriching experiences helped them perform at more advanced levels than those who had not had the experiences. While the sequential order of development was maintained according to Piaget's formulations, experience functioned to accelerate the rate of development.

Similarly in the present study, the conditioning and chaining sessions provided the infants experiences that seldom occur in the source of natural development at such early ages. Secondary circular reactions tend to be identified later in development because a certain level of motor development is required before the infant can begin to effect much control over objects in his environment. In this study the behaviors required were the vocalization and the leg kick which are readily available at 2 months. The E then provided situations in which these responses could effect changes in the environment with consistency and the possibilities of repetition. These two conditions are not usually available to the infant of 2 months. Even in the mothers' natural responses to their infants' vocalizations, there was often not much consistency. In providing a contingency situation, the operant method can be a valuable experience in the development of the infant. The operant situation offers opportunity for the infant to begin to experience himself as having some control over his environment. This is not the only relevant variable in the techniques used. Any time one expands the behavioral repetoire of the individual, the potential for further qualitatively different interactions with the environment is also increased.

There are two aspects of sensory-motor development in Piaget's theory. One is the vertical progression from one stage to the next as discussed earlier. The other is the extension and consolidation of the schemas and operations that define each stage, often referred to as the horizontal level. This horizontal level accounts for similarity in behavior of equal complexity and may be considered as indicative of generalization. When one cognitive developmental step is found, and there is a time lag between a similar cognitive development of the same order of complexity, horizontal decalage is said to have occurred. While there is no variance in the sequence of stages, the data from cross-sectional and longitudinal data suggest that infants under 2 years differ widely in the degree to which horizontal decalage takes place (Corman & Escalona, 1969). At each stage there is a group of schemas which are similar but which vary in complexity. The data suggest that an infant can move from one stage to another having achieved perhaps only a small proportion of the items associated with the horizontal level of the stage. It would seem that operant methods could be very useful in providing techniques by which one could determine how much generalization in schemas is necessary for the infant to move into the next level of complexity. It also offers a model for facilitating such generalization in its potential for providing a range of complexity in problem solving for the infant.

CHAPTER V

SUMMARY

Five 2-month-old infants were the Ss of this study. Of the 4 experimental Ss, 2 had their own mothers as a discriminative stimuli (S^D) during conditioning and chaining. Two had a mask as S^D; the fifth S was a control and received no conditioning. A series of baseline measures involving several stimulus conditions was taken before and after conditioning.

During conditioning the Ss were reinforced by mother's voice and tactile stimulation on the leg for vocalizing in the presence of the S^D. In chaining the appearance of the S^D was made by chance contingent on the leg kick response. When the S^D came into view, it set the occasion for the S to vocalize and to be reinforced. The data for 2 Ss during conditioning and 3 Ss during chaining indicated a significant increase in response rate sessions. The total session time was a critical variable for both conditioning and chaining.

Other relevant variables discussed included the difference in S^Ds, the baseline stimulus conditions, and activity ratings. Most of the changes in baselines taken after conditioning indicated an increase in vocalizations.

The findings were further discussed within the Piagetan framework of infant development. The behavior sequences established during

conditioning and chaining were defined as secondary circular reactions, and the data suggested that experience can facilitate the movement of the infant from one developmental stage into another. Directions for further research were suggested.

APPENDIX A

Activity Measures

Tracy was born 11-15-70 and was 72 days of age at the beginning of the study. She received the following activity ratings: (1) object offered = 1; (2) smiled at, talked to, touched by stranger = 1; (3) in seat = 1; (4) in stroller = 1; (5) smiled at and talked to by mother = 1. Average rating = 1.0. Mother described Tracy as a very contented baby who seldom cried, ate large amounts, slept for long periods during the day and through the night.

Brent was born 12-18-70 and was 74 days of age at the beginning of the study. He received the following activity ratings: (1) object offered = 1; (2) smiled at, talked to, touched by stranger = 2; (3) in seat = 2; (4) in playpen = 3; (5) smiled at and talked to by mother = 2. Average rating = 2.0. Mother described Brent as a very alert baby, awake most of the day, occasionally at night. He was content during the day as long as parent or sitter was visible and occasionally attentive.

David was born 1-10-71 and was 68 days of age at the beginning of the study. He received the following activity ratings: (1) object offered = 1; (2) smiled at, talked to, touched by stranger = 2; (3) in seat = 3; (4) in playpen = 3; (5) smiled at and talked to by mother = 3. Average rating = 2.4. Mother described David as having a terrible temper and as being a restless baby who had to be moved frequently.

Michele was born 1-13-71 and was 65 days of age at the beginning of the study. She received the following activity ratings: (1) object offered = 1; (2) smiled at, talked to, touched by stranger = 1; (3) in seat = 1; (4) in crib = 3; (4) smiled at and talked to by mother = 2. Average rating = 1.6. Mother described Michele as a good baby but finds it necessary to nurse her to sleep as she gets very upset if left to cry.

Lisa was born 12-26-70 and was 74 days of age at the beginning of the study. She received the following activity ratings: (1) object offered = 1; (2) smiled at, talked to, touched by stranger = 1; (3) in seat = 1; (4) in crib = 2; (5) smiled at and talked to by mother = 1. Average rating = 1.2. Mother described Lisa as a good-natured baby who sleeps a lot during the day and through the night.

APPENDIX B

Conditioning Response Rates per Minute

Tracy	Vocalization Rates	1.47	1.35	3.86	6.14	4.47	8.08	3.16	5.62
	Session Time (min.)	15	14	15	7	15	13	17	16
Brent	Vocalization Rates	4.53	7.30	5.13	4.21				
	Session Time (min.)	15	13	15	14				
Michele	Vocalization Rates	1.71	1.30	1.73	3.00	2.46	0.08		
	Session Time (min.)	7	10	15	11	13	10		
David	Vocalization Rates	5.75	3.00	2.00	3.70	5.80	2.84		
	Session Time (min.)	4	4	11	10	5	6		

Chaining Response Rates per Minute

Tracy	Leg Kick Rates	4.17	2.27	2.28	2.05				
	Vocalization Rates	4.80	2.11	6.40	7.36				
	Session Time (min.)	15	20	13	6				
Brent	Leg Kick Rates	4.12	2.47	3.28	2.72	3.24	5.77	2.60	7.29
	Vocalization Rates	5.94	9.20	9.09	8.08	9.72	4.41	7.18	8.05
	Session Time (min.)	13	15	15	13	15	13	15	11
Michele	Leg Kick Rates	2.37	2.45	4.31	5.51	3.68			
	Vocalization Rates	1.55	2.76	4.61	5.21	6.25			
	Session Time (Min.)	15	15	13	14	14			
David	Leg Kick Rates	0.91	2.37	3.57	2.70	1.36	1.56		
	Vocalization Rates	5.59	5.00	9.79	8.59	2.92	3.80		
	Session Time (min.)	13	15	10	11	15	12		

REFERENCES

Bijou, S. W. & Baer, D. M. Child Development I: A Systematic and Empirical Theory. New York: Appleton-Century-Crofts, Inc., 1961.

Bijou, S. W. & Baer, D. M. Child Development II: Universal Stage of Infancy. New York: Appleton-Century-Crofts, Inc., 1965.

Birch, H. G., Thomas, A., Chess, E., & Hertzig, M. E. Individuality in the development of children. Develpm. Med. Child Neurol., 1962, 4, 370-79.

Bower, T. G. R. Slant perception and shape constancy in infants. Science, 1966, 151, 832-34.

Brackbill, Y. Extinction of the smiling response in infants as a function of reinforcement schedule. Child Develpm., 1958, 29, 115-24.

Brennan, Wendy M., Ames, Elinor W., & Moore, Ronald W. Age differences in infants' attention to patterns of different complexities. Science, 1966, 151, 354-56.

Caron, Rose F. Visual reinforcement of head turning in young infants. J. Exp. Child Psychol., 1967, 5, 489-511.

Corman, Harvey, H. & Escalona, Sibylle K. Stages of sensorimotor development: a replication study. Merrill-Palm. Quart., 1969, 15, 351-61.

Engen, L., Lipsitt, L. P., & Kaye, H. Olfactory responses and adaptation in the human neonate. J. Comp. Physiol. Psychol., 1963, 56, 73-77.

Escalona, Sibylle K. The Roots of Individuality. Chicago: Aldine Publishing Co., 1968.

Fantz, R. L. Visual experience in infants: decreased attention to familiar patterns relative to novel ones. Science, 1964, 146, 668-70.

Fantz, R. L. Visual perception and experience in early infancy: a look at the hidden side of behavior development. In Stevenson, H. W., Hess, E. H., and Rheingold, H. L. (Eds.) Early Behavior. New York: John Wiley & Sons, Inc., 1967.

Fantz, R. L. A method for studying early visual development. Percept. Met. Skills, 1956, 6, 13-15.

Fantz, R. L. & Nevis, Sonia. Pattern preference and perceptual cognitive development in early infancy. Merrill-Palm. Quart., 1967, 13, 77-108.

Ferster, C. B. & Skinner, B. F. Schedules of Reinforcement. New York: Appleton-Century-Crofts, Inc., 1957.

Fitzgerald, H. E. & Porges, S. W. A decade of infant conditioning and learning research. Paper presented at the Merrill-Palmer Institute Conference on Research and Teaching of Infant Development, February 12, 1970.

Flavell, J. H. The Developmental Psychology of Jean Piaget. Princeton, N. J.: D. Van Nostrand Co., Inc., 1963.

Flechsig, P. Die leitungsbahnen im gehirm und riickenmark des menchen auf grund entevicklungsgeschichtlicher untersuchungen. Leipzig: Wilhelm Engelmann, 1876.

Gewirtz, J. L. A learning analysis of the effects of normal stimulation, privation, and deprivation on the acquisition of social motivation and attachment. In B. M. Moss (Ed.) Determinants of Infant Behavior. New York: Wiley, 1961.

Horowitz, Frances. Infant learning and development: retrospect and prospect. Merrill-Palm. Quart., 1968, 13, 101-21.

Hunt, J. M. Experience and development of motivation: some reinterpretations. Child Develpm., 1960, 31, 489-504.

Hunt, J. M. Intelligence and Experience. New York: Ronald Press, 1961.

Hunt, J. M. The impact and limitations of the giant of developmental psychology. In Elkind, David & Flavell, John H. (Eds.) Studies in Cognitive Development. New York: Oxford University Press, 1969.

Kagan, J. & Lewis, M. Studies of attention in the human infant. Merrill-Palm. Quart., 1965, 11, 95-127.

Kantrow, R. W. An investigation of conditioned feeding responses and concomitant adaptive behavior in young infants. Univer. Ia. Stud. Child Welf., 1937, 13, 3.

Kasathin, N. J. Early ontogenesis of reflex activity in the child. Zhurnal vysshey nervnoy deyatel nosti (translated by the USPHS), 1960, 6, 805-18.

Kelleher, Roger T. Chaining and conditioned reinforcement. In Honig, W. K. (Ed.) Operant Behavior. New York: Appleton-Century-Crofts, Inc., 1966.

Kelleher, Roger T. and Gollub, Louis R. A review of positive conditioned reinforcement. J. Exp. Anal. Behav., 1962, 5, 1, 543-97.

Koch, J. Conditioned orienting reactions to persons and things in 2-5 month old infants. Human Develpm., 1968, 11, 81-91.

Krasnogorski, N. Uber. Die Bedingungsreflexe im Kindesalter. Johrb. f. Kinderh., 1909, 69, 1-24.

Levinson, C. A. & Levinson, P. K. Operant conditioning of head turning for visual reinforcement in 3 month old infants. Psychonomic Science, 1967, 8, 529-30.

Lewis, M., Kagan, J, & Kalafat, J. Patterns of fixation in young infants. Child Develpm., 1966, 37, 331-339.

Lindsley, O. R. Experimental analysis of social reinforcement: terms and methods. Amer. J. Orthopsychiatry, 1963, 33, 624-33.

Ling, B. C. Form discrimination as a learning cue in infants. Comp. Psychol. Monogr., 1941, 17, 2, 66.

Lipsitt, L. P. Learning processes of human newborns. Merrill-Palm. Quart., 1966, 12, 45-71.

Lipsitt, L. P. Learning in the first year of life. In Lipsitt, L. P. & Spiker, C. C. (Eds) Advances in Child Development and Behavior. Vol. 1, New York: Academic Press, 1963.

Lipsitt, L. P. Learning in the human infant. In Stevenson, H. W., Hess, E. H. & Rheingold, H. L. (Eds.) Early Behavior: Comparative and Developmental Approaches. New York: Wiley & Sons, 1967.

Lipsitt, L. P. & Kaye, H. Conditioned sucking in the human newborn. Psychonomic Science, 1964, 1, 29-30.

Marquis, D. P. Can conditioned responses be established in the newborn infant? J. Genet. Psychol., 1931, 39, 479-92.

Marquis, D. P. Learning in the neonate: the modification of behavior under three feeding schedules. J. Exp. Psychol., 1941, 29, 263-82.

Morgan, J. J. B. & Morgan, S. S. Infant learning as a developmental index. J. Genet. Psychol., 1944, 65, 281-89.

Papousek, H. A method of studying conditioned food reflexes in young children up to age 6 months. Pavlov J. Higher Nerv. Activ., 1959, 9, 136-40.

Pavlov, I. P. Conditioned Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex. Translated & Edited by G. V. Anrep. Oxford: University Press, 1927.

Reynolds, G. S. A Primer of Operant Conditioning. Atlanta: Scott, Foresman, and Co., 1968.

Reynolds, G. S. Behavioral contrast. J. Exp. Anal. Behav., 1961, 4, 57-71.

Rheingold, H. L., Gewirtz, J. L., & Ross, H. W. Social conditioning of vocalizations in the infant. J. Comp. and Physiol. Psychol., 1959, 52, 68-73.

Rovee, C. K. & Rovee, D. T. Conjugate reinforcement of infant exploratory behavior. J. Exp. Child Psychol., 1969, 8, 33-39.

Sheppard, W. C. Operant control of infant vocal and motor behavior. J. Exp. and Behav., 1969, 7, 36-51.

Sidman, Murray. Tactics of Scientific Research. New York: Basic Books, Inc., 1960.

Sigel, I. R. Introduction to 1967 infant conference papers. Merrill-Palm. Quart., 1968, 14, 3.

Simmons, M. W. & Lipsitt, L. P. An operant discrimination apparatus for infants. J. Exp. Anal. Behav., 1961, 4, 233-35.

Siqueland, E. Technics for investigation of conditioned head turning in infants. Paper presented at Soc. Res. Child Develop., Minn., March, 1965.

Siqueland, E. & Lipsitt, L. P. Conditioned head turning in infants. J. Exp. Child Psychol., 1966, 3, 374-76.

Skinner, B. F. The Behavior of Organisms. New York: D. Appleton-Century Co., Inc., 1938.

Skinner, B. F. A case history in scientific method. Amer. Psychol., 1956, 11, 221-33.

Skinner, B. F. Operant behavior. In Honig, Werner K. (Ed.) Operant Behavior. New York: Appleton-Century-Crofts, 1966.

Skinner, B. F. & Morse, W. H. Concurrent activity under fixed-interest reinforcement. J. Comp. & Physiol. Psychol., 1957, 50, 279-81.

Spears, W. C. Assessment of visual preference and discrimination in the four-month-old infant. J. Comp. Physiol. Psychol., 1964, 57, 381.

Spiker, C. C. Research methods in children's learning. In P. H. Mussen (Ed.) Handbook of Research Methods in Child Development. New York: Wiley & Sons, 1960.

Stern, E. R. & Jeffrey, W. E. Operant conditioning of nonnutritive sucking in the neonate. Paper presented at the biennial meeting of the Soc. Res. Child Develop., Minn., April, 1965.

Terrace, H. S. Stimulus control. In Honig, Werner K. (Ed.) Operant= Behavior. New York: Appleton-Century-Crofts , 1966.

Watson, J. S. The development and generalization of contingency awareness in early infancy: some hypotheses. Merrill-Palm. Quart., 1966, 13, 123-35.

Watson, J. S. Operant conditioning of visual fixation in infants under visual and auditory reinforcement. Develpm. Psychol., 1969, 15, 508-15.

Weisberg, P. Social and nonsocial conditioning of infant vocalizations. Child Develpm., 1963, 34, 377-88.

Wenger, M. A. Investigation of conditioned responses in human infants. Univ. Ia. Stud. Child Welf., 1936, 12, 11-90.

White, Burton L. The initial coordination of sensorimotor schemas in human infants: Piaget's ideas and the role of experience. In Elkind, David & Flavell, John H. (Eds.) Studies in Cognitive Development. New York: Oxford University Press, 1969.

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Kathryn Fentress Harry is married to Robert Porter Harry, and they have two children, Margaret and Robert.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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